288AX

HICKOK

INSTRUCTION MANUAL

for

# MODEL 288AX

# UNIVERSAL CRYSTAL CONTROLLED SIGNAL GENERATOR

Manual No. 2490-585

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# UNIVERSAL CRYSTAL CONTROLLED SIGNAL GENERATOR MODEL 288AX

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19120-153

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# TECHNICAL DATA SHEET

| Quan. | Name | Type | Stock No. | Dimensions | Weight |
|---|---|---|---|---|---|
| 1 | Universal Crystal Controlled Signal Generator | 288AX | 902-369 | 14½"x18"x7" | 30 lbs. |
| 1 | Instruction Book | | 2490-414 | | |
| 1 | Cable Assembly | | 3030-41 | 48" | |
| 1 | Meter Lead | | 12450-98 | 48" | |

## TECHNICAL CHARACTERISTICS

1. Power Supply Required: 105-125V, 60 cycles, a-c

2. Power Consumption: 30 watts at 115 volts

3. Amplitude Modulated - Pure R-F Frequency Ranges:

   a. A Band 35-110 Kc
   b. B Band 110-300 Kc
   c. C Band 300-850 Kc
   d. D Band 850-2200 Kc
   e. E Band 2.2-6.5 Mc
   f. F Band 6.5-20 Mc
   g. G Band 20-50 Mc
   h. H Band 50-110 Mc

4. Frequency Modulated R-F Frequency Ranges:

   a. Narrow Band (0-30 Kc Sweep): 100 Kc to 110 Mc in 7 ranges
   b. Wide Band (0-150-450 Kc Sweep): 1 Mc to 160 Mc in 7 ranges

5. Modulation:

   a. Amplitude Modulation: 400 cycle
   b. Frequency Modulation: 40 Mc, 0-450 Kc variable sweep, modulating frequency - 60 cycles

      50 Mc, 0-150 Kc variable sweep, modulating frequency - 400 cycles

      1000 Kc, 0-30 Kc variable sweep, modulating frequency - 60 cycles

   c. External Modulation: Frequency Modulation, variable 0-15,000 cycles
      Amplitude Modulation, variable 0-15,000 cycles

6. A-F Range: Fixed at 400 cycles
   Variable from 20-15,000 cycles

7. Crystal Controlled Output:

   a. 100 Kc, Unmodulated: 100-15,000 Kc (utilizing harmonics)

b. 100Kc, 400 cycle Amplitude Modulated: 100-15,000 Kc (utilizing harmonics)
c. 1000Kc, Unmodulated: 1000 Kc - 125 Mc (utilizing harmonics)
d. 1000Kc, 400 cycle Amplitude Modulated: 1000 Kc - 125 Mc (utilizing harmonics)

8. Output: R-F - continuously variable from 0 to maximum (with multipliers X1, X10 and X1000)

A-F - continuously variable from 0 to maximum, linear control, for both 400 cycle and variable outputs

Synchronized Sweep Voltage: For horizontal deflection of oscillograph (60 cycle)

9. DB Meter Range: -10 to +6, +6 to +22, +22 to +38

10. Tube Complement:

| | Tube | Stock No. | Function |
|---|---|---|---|
| V1 | 6C4 | 20875-62 | Main variable r-f oscillator |
| V2 | 6SN7GT | 20875-19 | Crystal oscillator amplifier |
| V3 | 6SN7GT | 20875-19 | Frequency modulated oscillator and mixer |
| V4 | 6SK7 | 20875-18 | Negative resistance oscillator, 400 cycle, fixed, and 0-15 Kc, variable, a-f |
| V5 | 6X5GT | 20875-22 | Full-wave rectifier |
| V6 | 6SG7 | 20875-63 | Reactance control tube |
| | #47G. E. | 12270-12 | Pilot lamp |

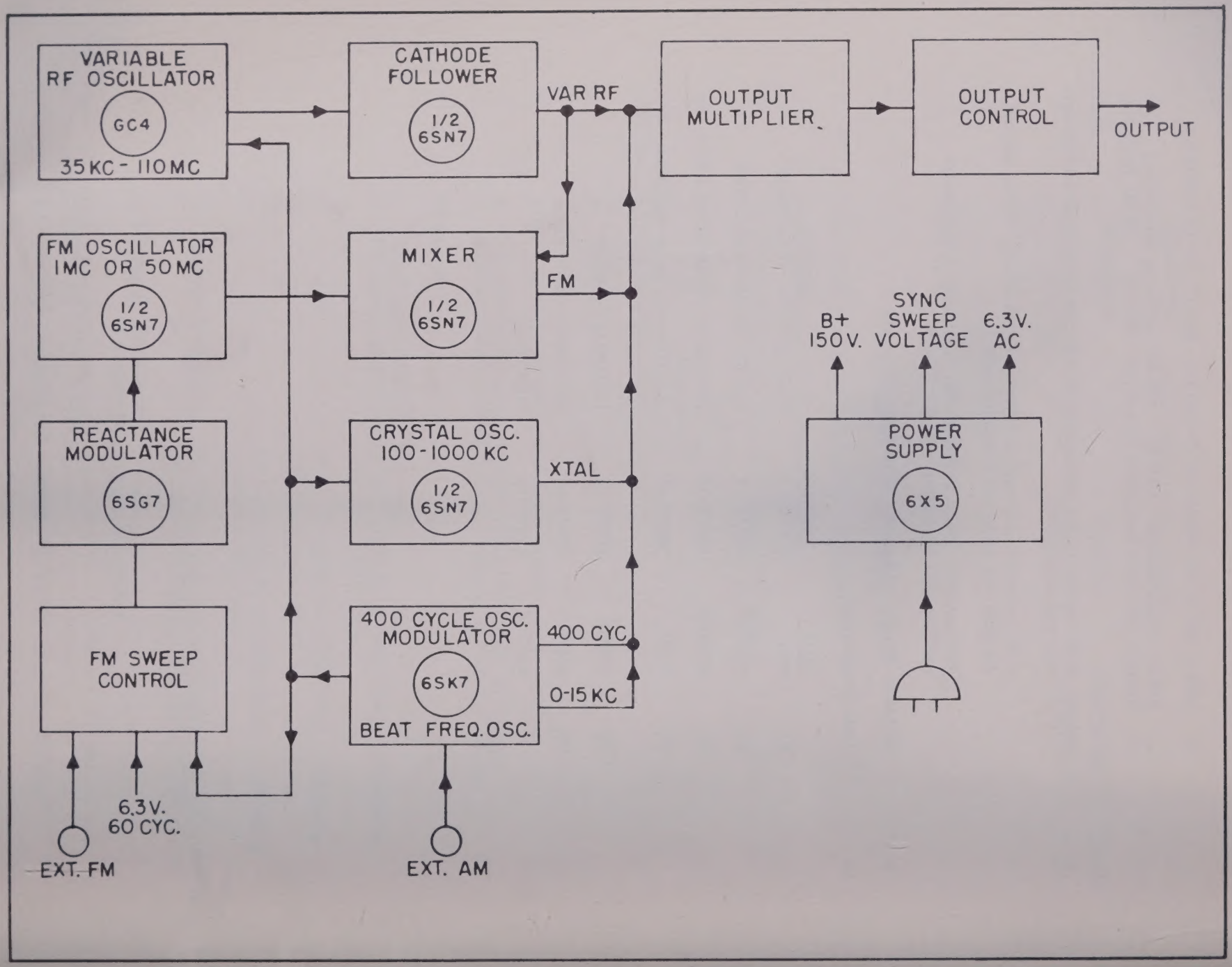



FIGURE 1.2 - BASIC CIRCUIT, BLOCK DIAGRAM, MODEL 288X

## SECTION I - DESCRIPTION

### 1.1 GENERAL

a. The Model 288AX Universal and Crystal Controlled Signal Generator is a portable instrument, complete with crystal and test leads, ready for immediate operation after unpacking.

### 1.2 PURPOSE

This Universal and Crystal Controlled Signal Generator is specifically designed to meet the many and varied needs of the radio engineer and service man working with frequency and amplitude modulated receivers and with television equipment. The wide range in radio-frequencies and audio-frequencies available, with the many choices of type of modulation makes this model a most versatile and practical instrument.

### 1.3 BRIEF DESCRIPTION

a. Physical

The Model 288AX, with decibel meter and crystal, is illustrated in Figure 1.1. All panel controls, scales and connectors are clearly marked.

b. Functional

The Model 288AX will perform the following electrical functions:

1. Produce frequency modulated signal - variable with respect to bandwidth, frequency and output level - for testing and alignment of frequency modulated receivers, amplitude modulated receivers and television equipment.

2. Produce amplitude modulated or unmodulated signal - variable with respect to frequency and output level - for testing and alignment of amplitude modulated receivers and other electronic devices requiring a wide range in amplitude modulated or unmodulated signals.

3. Produce an audio frequency signal - variable with respect to frequency and output level - for testing audio amplifiers and speakers.

4. Produce an accurate crystal controlled signal of 100 kc or 1000 kc - amplitude modulated or unmodulated. When the harmonics are utilized it is especially adaptable for easily checking dial calibration of the receivers.

5. Indicate and measure voltage and power outputs by means of the self-incorporated decibel meter.

c. Electrical

The basic circuit of a Model 288AX is shown in block diagram form in Figure 1.2. The circuit will be explained more fully in Section II, Theory.

d. Components

The a-c line cord is permanently attached to the signal generator. A red unshielded lead, 48" long, with an alligator clip on one end and a pin tip on the other is furnished for the decibel meter, and a 48" cable with connector and two clips is furnished for the output.

## SECTION II - THEORY

### 2.1 GENERAL

A thorough understanding of the theory of the operation of any instrument will enable the user to obtain greater utility and satisfaction from the instrument. For this reason the following brief explanation of the Hickok Model 288AX is given.

### 2.2 POWER SUPPLY

The power supply is a conventional type operating from a 105-125 volt, 60 cycle a-c power supply line. Each side of the primary of the transformer is bypassed to ground through a capacitor which serves as a filter for the radio frequency to prevent its leakage back through the power supply main. A high voltage secondary winding is center-tapped to ground and supplies approximately 175 volts from each winding to ground. A 6.3 volt winding, one side of which is at ground, supplies the heater voltage for all tubes. The type 6X5GT rectifier tube V5, and filter network are conventional and supply approximately 150 volts d-c at approximately 35 mils.

### 2.3 RF MAIN VARIABLE OSCILLATOR

The main variable oscillator covers a frequency range of 35 kc to 110 mc in eight bands. It consists of a type 6C4 miniature ultra-high frequency oscillator tube, V1, used in a shunted Colpitts type oscillator circuit with tuning accomplished by means of a split stator variable air condenser, together with eight coils. The first seven of these coils are trimmed for capacity and also permeability tuned for inductance by means of powdered iron core tuning slugs.

### 2.4 RF AMPLIFIER

The output of the main variable oscillator is fed to a cathode follower consisting of one-half of a type 6SN7 tube, V2, which isolates the main oscillator from the OUTPUT MULTIPLIER. The output impedance of the amplifier is made very low so that the output voltage can be made almost independent of the load to which it is connected.

### 2.5 400 CYCLE MODULATOR - BEAT FREQUENCY OSCILLATOR

A type 6SK7 tube, V4, is used in a negative resistance oscillator circuit to generate either 400 cycle audio frequency or approximately 160 to 175 kc radio frequency. When used as a 400 cycle audio frequency oscillator, the output of this oscillator is used to modulate either the main variable oscillator at 400 cycles, at approximately 30% modulation, or it may be used to modulate the wide band frequency modulated oscillator, bandwidth variable 0-150 kc. When used as a radio frequency oscillator, at 160 to 175 kc, the output of this oscillator is heterodyned in the 6SN7, V3, mixer circuit with the main variable oscillator so that the mixed output will be a variable audio frequency from 0-15 kc.

### 2.6 FM OSCILLATOR - MIXER

a. The main characteristic of a frequency modulated signal is that the frequency is constantly changing while the output voltage remains constant. Starting at the fundamental frequency, the frequency gradually increases to its maximum, decreased through the fundamental to its minimum and then returns to the fundamental frequency, completing the cycle. The maximum and minimum frequencies are determined by the bandwidth of the f-m oscillator. In the Universal and Crystal Controlled Signal Generator the bandwidth may be either 0-30 kc, 0-150 kc or 0-450 kc. The rate at which the cycle is completed may also be variable. In these models the rate is either 60 or 400 cycles.

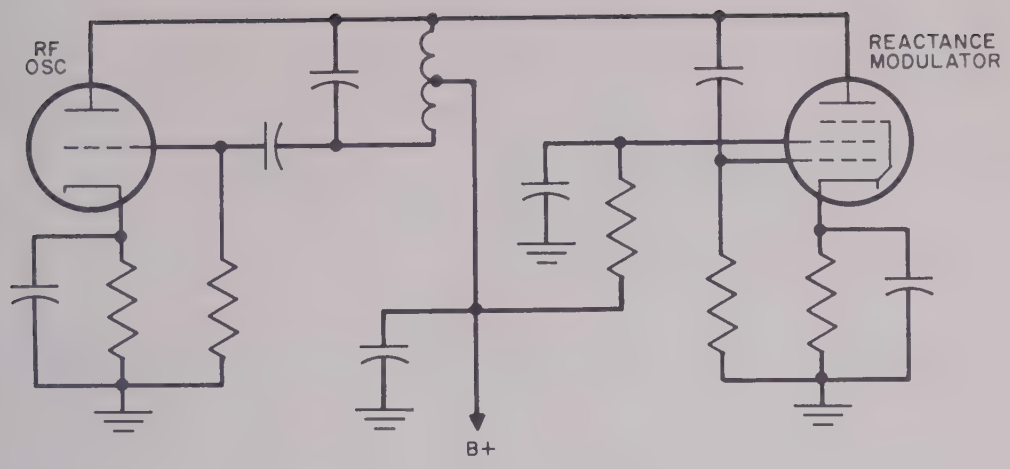



FIG. 2.1 REACTANCE MODULATOR

One-half of a type 6SN7 tube, V3, is used as a triode r-f oscillator to operate at either 1 mc or at 50 mc. Either of these signals may be frequency modulated by means of a type 6SG7 reactance tube, V6. The reactance modulator grid is driven by a small signal from the oscillator. The coupling capacitor and grid resistor develop a leading phase shift of the signal. When amplified, this grid signal results in a capacitive reactance appearing in parallel with the oscillator tuned circuit. The sweep control adjustment varies the amplitude of the signal, resulting in an adjustable capacitive reactance across the oscillator tank circuit which changes the oscillator frequency at a rate corresponding to the sweep frequency. In the case of the narrow band f-m oscillator (1 mc), the sweep may be varied from 0-30 kc, utilizing 60 cycle modulating frequency. When using the wide band r-m oscillator (50 mc) the sweep may be varied from 0-450 kc utilizing 60 cycle modulation or 0-150 kc utilizing 400 cycle modulation. The oscillator can also be externally modulated. The remaining section of the 6SN7, V3 is used as a mixer stage to heterodyne either the 1 mc or 50 mc frequency modulated signal with the signal from the main variable oscillator, thereby resulting in a variable frequency FM output covering a range from 100 kc to 160 mc.

## 2.7 CRYSTAL OSCILLATOR

A dual frequency crystal oscillator is incorporated, utilizing one-half of a type 6SN7 tube, V2, to provide output frequencies of either 100 kc or 1000 kc. The crystal controlled output voltage is fed to the OUTPUT MULTIPLIER network.

## 2.8 OUTPUT MULTIPLIER

The output multiplier circuit of the Model 288AX consists of a two-section, five-position switch and associated components, including the potentiometer control. In the 400 cycle A-F position, the output from the secondary winding of the audio frequency transformer is fed directly to the OUTPUT control and then to the output cable. The 0-15 Kc AF FM position connects the output from the plate of the mixer tube to the OUTPUT control directly, and then to the output cable. In positions RF X1, X10 and X1000, the output is attenuated by means of an attenuator network before appearing at the output cable.

## 2.9 DECIBEL METER

The decibel meter consists of a conventional copper oxide rectifier meter and its associ-

ated circuit. The meter may be used to measure output voltages ranging from zero to 140 volts or decibel power levels ranging from -10 DB to +39 DB. As the DB meter scale is calibrated on the basis of 0 DB = .006 watts (6 mw) when used across a 500 ohm termination, the voltage readings and DB readings correspond only when the meter is connected across a 500 ohm termination. There is a blocking condenser in the decibel meter circuit which permits its use in circuits having a d-c component. The frequency characteristics of the decibel meter are such that negligible error will be encountered throughout the audio frequency spectrum to approximately 10,000 cycles.

## SECTION III - OPERATION

### 3.1 CONTROLS AND THEIR FUNCTIONS

a. The location of the controls of the Model 288AX is shown in Figure 1.1 and a brief explanation of their function is given in subsequent paragraphs to facilitate their use in obtaining the desired output.

b. FREQUENCY MODULATED SWEEP - a dual purpose control which is used as the a-c line power switch and also as a control of the bandwidth of the sweep for frequency modulated output. To place the instrument in operation, turn the control clockwise until the line switch is closed which will be indicated by an audible clock and the lighting of the pilot light. The position of this control, when not operating as a bandwidth sweep control, has no effect on the operation of the equipment.

c. BAND SELECTOR - An eleven-position control: the first eight positions, Bands A through H, select various frequency ranges from 35 kc to 110 mc, the next two positions select either the 100 kc or 1000 kc crystal frequency and the last position selects the 0-15 kc audio frequency.

d. FREQUENCY ADJUSTMENT - Control of the frequency within the range selected by the BAND SELECTOR switch. Calibration of the dial permits interpolation of the scale if desired.

e. OUTPUT CONTROL - Linear potentiometer control of the r-f and a-f output voltage of the signal generator.

f. OUTPUT MULTIPLIER - A five-position control of the output of the signal generator. Positions RF X1, RF X10 and RF X1000, are the three output levels of r-f signal. Position 0-15Kc AF FM, in conjunction with the OUTPUT SELECTOR switch, selects either the 0-15 Kc audio frequency output or any of the frequency modulated outputs. Position 400 $\sim$ AF selects the 400 cycle, fixed, audio frequency output as an audio signal or for amplitude modulation.

g. FM - AM SELECTOR - A three position control:

1. AMPLITUDE MODULATED for all outputs other than frequency modulated outputs.

2. 1000 KC 30 KC SWEEP for the 1000Kc signal frequency modulated with a band width of 0-30 Kc.

3. 50 MC 450 KC SWEEP for the 50 Mc signal frequency modulated with a bandwidth of either 0-150 Kc or 0-450 Kc.

h. OUTPUT SELECTOR - A five-position switch selecting the various types of outputs.

1. OFF EXT for unmodulated radio frequency output or either frequency or ampli-

## OPERATION CHART

| SIGNAL OUTPUT * See Note 4 | FREQ MOD SWEEP | OUTPUT SELECTOR | BAND SELECTOR | FREQUENCY ADJUSTMENT | OUTPUT CONTROL | OUTPUT MULTIPLIER | FM-AM SELECTOR | VARIABLE AUDIO FREQUENCY |
|---|---|---|---|---|---|---|---|---|
| 1. Unmodulated RF 35KC-110MC | Power ON | OFF EXT | Desired frequency range | Desired frequency | Adjust control for the desired output level | Desired RF multiplying factor | AMPLITUDE MODULATED | Control may be left in any position except when Audio Frequency 0-15 KC output is desired, then setting of control will be dependent upon the audio frequency desired, 0 - 15 KC. |
| 2. Amplitude Modulated RF 35 KC - 100 MC | | | | | | | | |
| a. 400 , Fixed | Power ON | 400 AMP | Desired frequency range | Desired frequency | | Desired RF multiplying factor | AMPLITUDE MODULATED | |
| b. Externally Modulated | Power ON | OFF EXT | Desired frequency range | Desired frequency | | Desired RF multiplying factor | AMPLITUDE MODULATED | |
| 3. Frequency Modulated RF 100 KC - 110 MC | | | | | | | | |
| a. 1000 KC, 0-30 KC Sweep | Power ON, 0-30 | 60 FREQ | Desired frequency range. See Note 1 | Desired frequency. See Note 1 | | 0-15 KC AF FM | 1000 KC 30 KC SWEEP | |
| 150 KC - 160 MC | | | | | | | | |
| b. 50 MC, 0-150 KC Sweep | Power ON, 0-150 | 400 FREQ | Desired frequency range. See Note 2 | Desired frequency. See Note 2 | | 0-15 KC AF FM | 50 MC 450 KC SWEEP | |
| 450 KC - 160 MC | | | | | | | | |
| c. 50 MC, 0-450 KC Sweep | Power ON, 0-450 | 60 FREQ | Desired frequency range. See Note 2 | Desired frequency. See Note 2 | | 0-15 KC AF FM | 50 MC 450 KC SWEEP | |
| d. 50 MC, Externally Modulated 0-15 KC Sweep | Power ON | OFF EXT | Desired frequency range. See Note 2 | Desired frequency. See Note 2 | | 0-15 KC AF FM | 50 MC 450 KC SWEEP | |
| 4. Audio Frequency, 0-15 KC | Power ON | 0-15 KC AF | 0-15 KC AF | See Note 3 | | 0-15 KC AF FM | AMPLITUDE MODULATED | |
| 5. Audio Frequency, 400 Fixed | Power ON | 400 AMP | Any position | Any position | | 400 AF | AMPLITUDE MODULATED | |
| 6. Frequency Modulated AF | Power ON, 15 | 60 FREQ | D | 985 or 1015 Kc | | 0-15 KC AF FM | 1000 KC 30 KC SWEEP | |
| 7. Crystal Controlled Frequency | | | | Any | | | | |
| a. 100 KC, Unmodulated | Power ON | OFF EXT | 100 KC | Any position | | Desired RF multiplying Factor. | AMPLITUDE MODULATED | |
| b. 100 KC, Modulated | Power ON | 400 AMP | 100 KC | Any position | | Desired RF multiplying Factor. | AMPLITUDE MODULATED | |
| c. 1000 KC, Unmodulated | Power ON | OFF EXT | 1000 KC | Any position | | Desired RF multiplying Factor. | AMPLITUDE MODULATED | |
| d. 1000 KC, Modulated | Power ON | 400 AMP | 1000 KC | Any position | | Desired RF multiplying Factor. | AMPLITUDE MODULATED | |

Note 1: This frequency will be the frequency which is either the sum or difference of 1000 KC and the desired frequency. I. e., for 456 Kc, i-f alignment, this frequency is either 1456 Kc or 544 Kc.

Note 2: This frequency will be the frequency which is either the sum or difference of 50 mc and the desired frequency. I. e., for 10.7 mc i-f alignment, this frequency is either 39.3 or 60.7

Note 3: This will be at approximately 170 kc, B Band. Adjustment should be made so zero beat is obtained with the VARIABLE AUDIO FREQUENCY control at 0 position.

Note 4: For connections of the Decibel Meter for any given test see Chart 1, page 11.

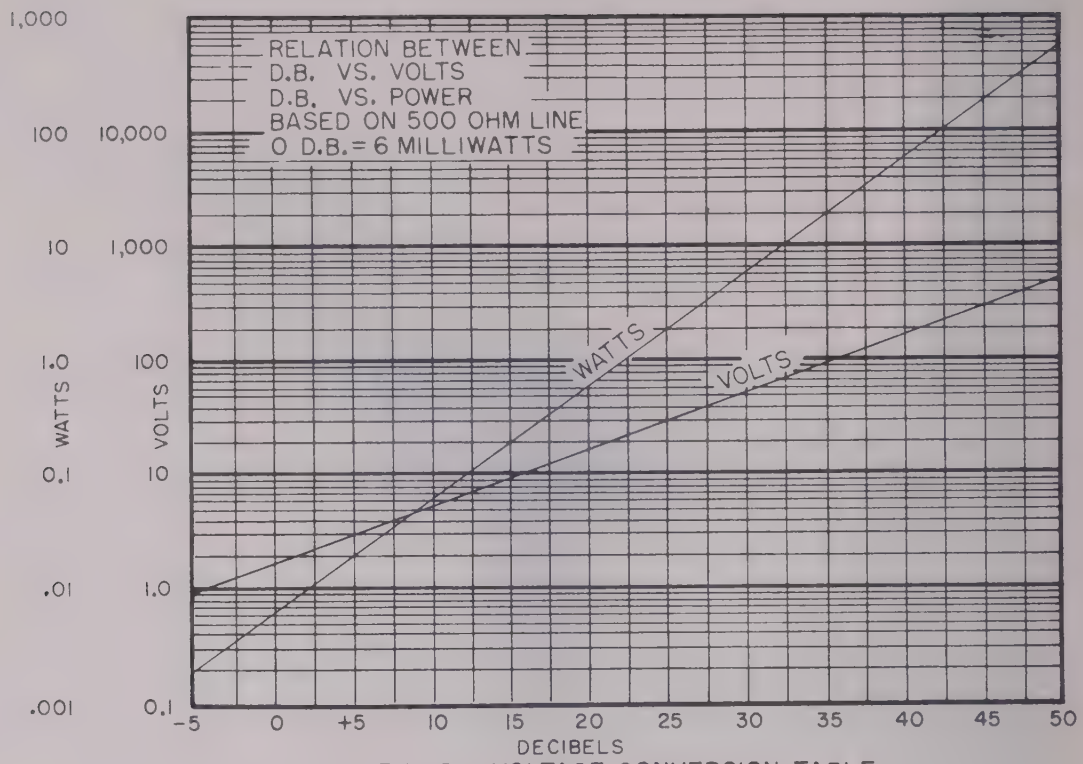



FIG. 3.1 DB-VOLTAGE CONVERSION TABLE

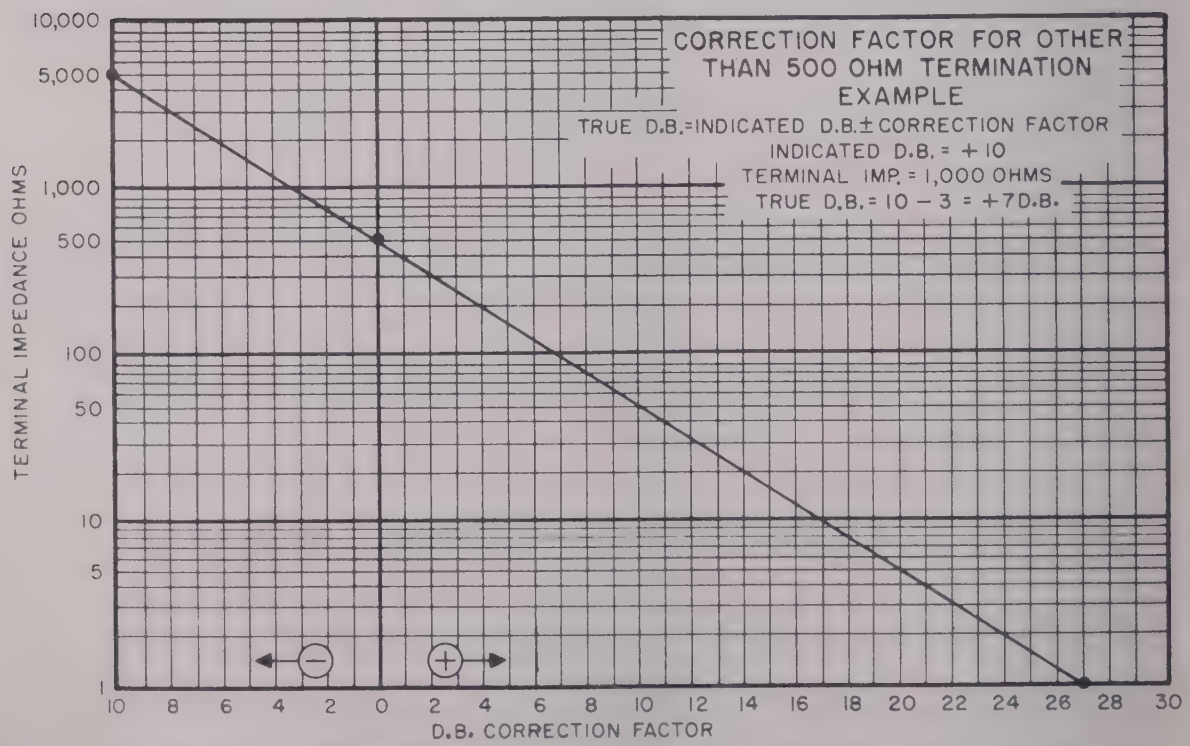



FIG. 3.2 CORRECTION FACTOR FOR OTHER THAN 500 OHM TERMINATION

tude modulation from an external source.

2. 400 oo AMP for 400 cycle amplitude modulation and for 400 cycle, fixed, audio frequency signal.

3. 400 oo FREQ for 400 cycle modulating frequency used for frequency modulating the 50 Mc, 0-150 Kc sweep output.

4. 60 oo FREQ for 60 cycle modulating frequency used for frequency modulating either the 1000 Kc, 0-30 Kc sweep, or 50 Mc, 0-450 Kc sweep, output.

5. 0-15 Kc AF for an audio frequency variable 0-15 Kc.

i. VARIABLE AUDIO FREQUENCY - a calibrated variable control of the audio frequency output from 0 to 15 kilocycles.

j. SYNCHRONIZED SWEEP VOLTAGE (Gnd-Output) (To be used in conjunction with cathode ray equipment) - Output connections for a 60 cycle voltage from the power supply for supplying the horizontal sweep of an oscilloscope.

k. EXTERNAL MODULATION (Amp - Freq) AMP: connection permitting amplitude modulation from an external source; FREQ: connection permitting frequency modulation from an external source.

l. PILOT - Indication of power being supplied the signal generator.

m. OUTPUT - Connector for shielded output cable for the output signal.

n. DECIBEL METER (-10 to +6, +6 to +22, +22 to +38) - pin jacks for connection to the combination a-c voltmeter and decibel meter at one of the three ranges available.

o. GROUND - Binding post for connecting the ground of the signal generator to that of any associated equipment; also is the ground connection for the DECIBEL METER.

3.2 OPERATION CHART

a. The operation chart indicates the proper setting for each control in order to obtain a given output. The sequence of operation is from left to right.

b. The generator normally operates from a 105-125 volt, 60 cycle, a-c power source, unless especially wired otherwise. As several minutes are required for the tubes to come up to stable operating temperatures and as the equipment draws only 30 watts, it is recommended that it be left on if it is to be used frequently throughout the day.

CAUTION

Do not connect the output of the signal generator across any source of appreciable voltage, either a-c or d-c. The internal resistance of the output network is very low and the application of an external voltage might damage the resistors in this network. If it is necessary to connect the output of the generator across a source of a-c or d-c voltage, a series condenser should be connected between the red output clip and the point at which the output voltage is being applied.

## 3.3 DECIBEL METER

ALWAYS start with the decibel meter connected at the highest range if the decibel level or the voltage to be measured is not known as this will minimize the possibility of damaging the meter due to overload.

a. Connect from the pin jack of the proper range to the equipment under test, using the GROUND BINDING post as the ground of the meter circuit.

b. Read the decibel level from the upper scale or the a-c voltage from the lower scale of the meter. A conversion chart, which evaluates the decibel or voltage reading in terms of power is given in Figure 3. 1. When the termination is other than a 500 ohm termination, use the correction factor chart given in Figure 3. 2.

c. The decibel or voltage value may be easily converted to a power reading by simply locating the known value on the correct curve and determining the associated power reading. The decibel meter is calibrated in terms of a matching load of 500 ohms. If the load across which measurement is to be made is other than 500 ohms, a correction factor is needed. The correction factor chart, shown in Figure 3. 2 will enable the user to determine this factor in terms of db.

# SECTION IV - APPLICATION

## 4.1 GENERAL

As the applications indicated here are general in nature, the specifications of the manufacturer should be consulted in making all tests. A basic circuit diagram of the seven tube amplitude modulated superheterodyne receiver which is referred to throughout the following discussions is shown in Figure 4. 1. Frequency modulated receiver circuits have, in addition to the stages shown, limiter and discriminator (2nd detector) stages.

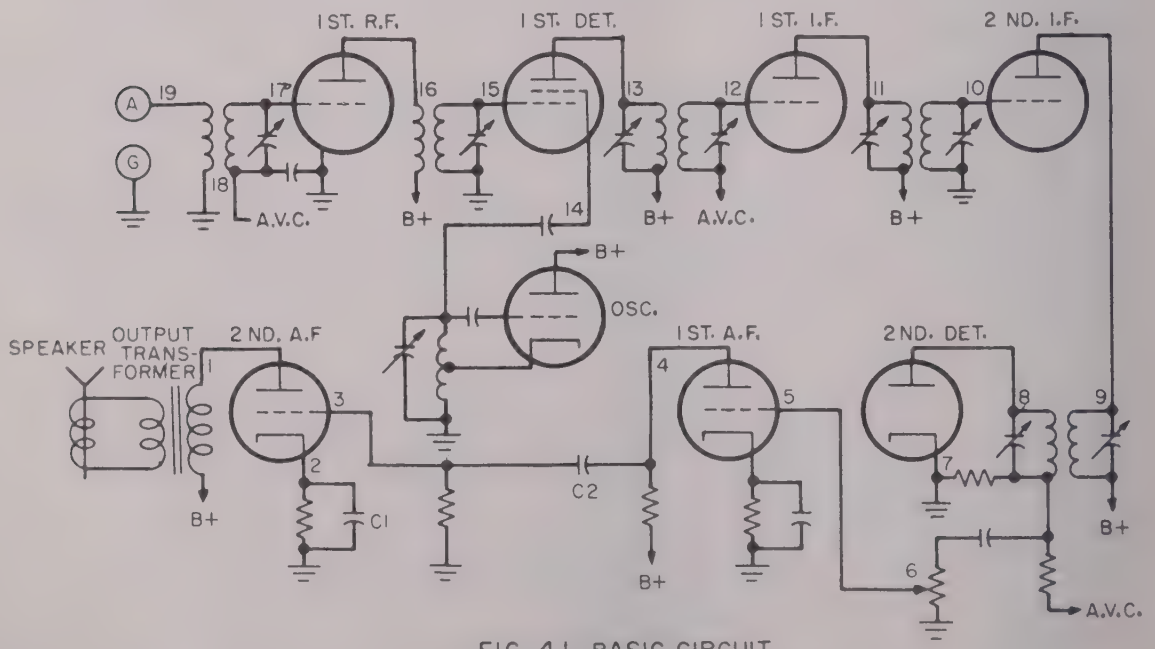



FIG. 4.1 BASIC CIRCUIT
SUPERHETERODYNE RECEIVER

## 4. 2 ALIGNMENT OF RADIO RECEIVERS

### a. I-F Alignment

1. Some intermediate frequency stages are tuned by means of trimmer condensers and others by means of variable powdered-iron core inductors. The object in i-f alignment is to adjust either until the maximum output is obtained as indicated by the indicating means used. This indicating means may be either vacuum tube voltmeter, decibel meter, a-c voltmeter, or oscilloscope in the case of amplitude modulated receivers but an oscilloscope should be used in the case of frequency modulated receivers.

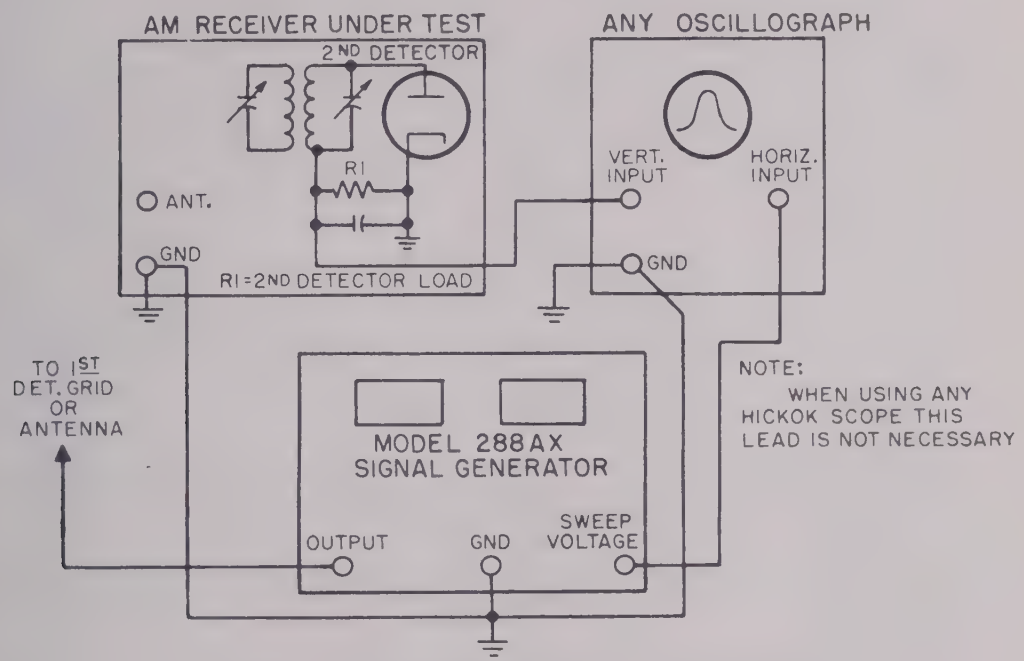



FIG. 4.2 – INTERCONNECTIONS FOR ALIGNMENT

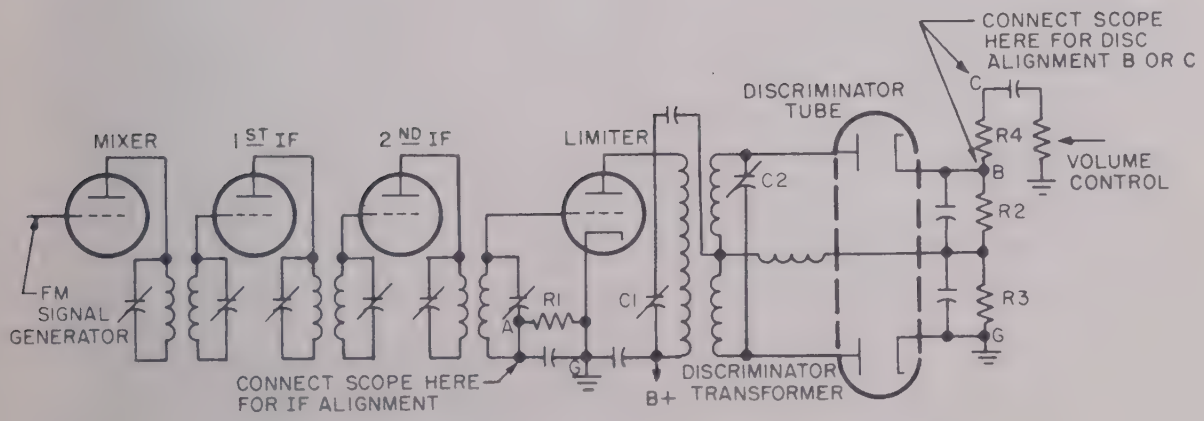



FIG. 4.3 FOSTER – SEELEY DISCRIMINATOR CIRCUIT

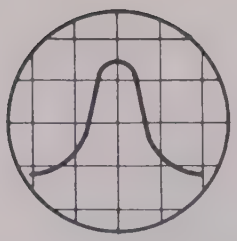


FIG. 4.4

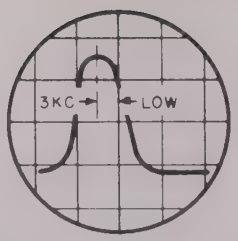



FIG. 4.5

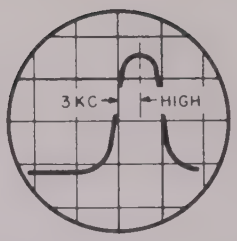



FIG. 4.6

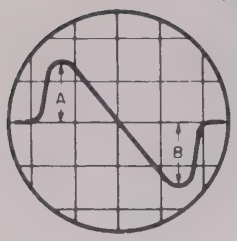



FIG. 4.7

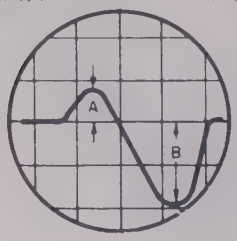



FIG. 4.8

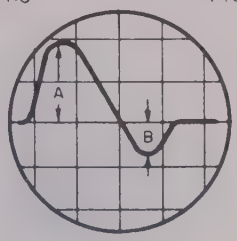



FIG. 4.9

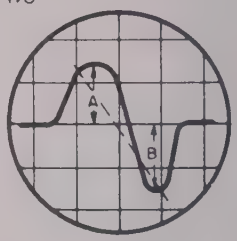



FIG. 4.10

FIGURE 4.4 – CORRECT ALIGNMENT, ANY STAGE

FIGURE 4.5 – CORRECT ALIGNMENT, ANY STAGE, TUNED BELOW PROPER FREQUENCY

FIGURE 4.6 – CORRECT ALIGNMENT, ANY STAGE, TUNED ABOVE PROPER FREQUENCY

FIGURE 4.7 – DISCRIMINATOR TRANSFORMER, CORRECT ALIGNMENT

FIGURE 4.8 – 4.9 – DISCRIMINATOR TRANSFORMER, C2, IMPROPERLY ADJUSTED $A = E_{R2}$ $B = E_{R3}$

FIGURE 4.10 – DISCRIMINATOR TRANSFORMER, SECONDARY CORRECTLY ALIGNED, PRIMARY INCORRECTLY ALIGNED

## ALIGNMENT CHART FOR BROADCAST RECEIVERS
(Chart 1)

The following chart summarizes the alignment effected, the signals required, the indicating medium required, the points of connection for both, and the alignment adjustment necessary for the alignment of the stages of both amplitude and frequency modulated receivers. In conjunction with this chart, reference is made to the text for greater detail on the alignment to be made and to Figure 4. 2 which shows the interconnections of the oscillograph, signal generator and the receiver. All points given are with reference to the basic circuit of the superheterodyne receiver, illustrated in Figure 4. 1, and the discriminator circuit illustrated in Figure 4. 3. The oscillograms which will be obtained when making alignment by means of the oscilloscope are shown in Figure 4. 4 - 4. 10.

| Stage A-M | Freq. | Signal Type | Connect Signal Generator | Type Indicator | Connect Indicator | Align |
|---|---|---|---|---|---|---|
| A-M Receivers | | | | | | |
| I-F | I-F | Unmod | 1st det. Grid | VTVM | 2nd det. load | I-f transformers |
| I-F | I-F | A-M 400 | 1st det. Grid | DB Meter | A-F stage | I-f transformers |
| I-F | I-F | F-M 30kc sweep | 1st det. Grid | Scope | 2nd det. load | I-f trimmer, see Figures 4.4, 4.5 |
| OSC | 550 kc | Unmod | Ant. | VTVM | 2nd det. load | Osc padder |
| OSC | 1500 kc | Unmod | Ant. | VTVM | 2nd det. load | Osc trimmer |
| OSC | 550 kc | A-M 400 | Ant. | DB Meter | A-F stage | Osc padder |
| OSC | 1500 kc | A-M 400 | Ant. | DB Meter | A-F stage | Osc trimmer |
| OSC | 550 kc | F-M 30kc sweep | Ant. | Scope | 2nd det. load | Osc padder, see Figures 4.4, 4.6 |
| OSC | 1500 kc | F-M 30kc sweep | Ant. | Scope | 2nd det. load | Osc trimmer, see Figures 4.4, 4.6 |
| RF | 1500 kc | Unmod | Ant. | VTVM | 2nd det. load | R-F trimmers |
| RF | 1500 kc | A-M 400 | Ant. | DB Meter | A-F stage | R-F trimmers |
| RF | 1500 kc | F-M 30kc sweep | Ant. | Scope | 2nd det. load | Trimmers, see Figures 4. 4, 4.6 |
| F-M Receivers | | | | | | |
| I-F | I-F | F-M 450 kc sweep | 1st det. Grid | Scope | Limiter resistor, R1 | I-f, see Figure 4. 4 |
| Disc-Pri | I-F | F-M 450 kc sweep | 1st det. Grid | Scope | Disc load resistor, R2-R3 | Disc pri - see Figures 4.7, 4.10 |
| Disc-sec | I-F | F-M 450 kc sweep | 1st det. Grid | Scope | Disc load resistor, R1-R3 | Disc sec - see Figures 4.7, 4.10 |
| OSC | 90 mc | F-M 450 kc sweep | Ant. | Scope | Disc load resistor, R1-R3 | Osc trimmer to center pattern, Figure 4. 7 |
| OSC | 106mc | F-M 450 kc sweep | Ant. | Scope | Disc load resistor, R1-Re | Check for Figure 4. 7 |

2. Feed the output of the signal generator, tuned to the proper i-f frequency (determined from manufacturer's specifications), in accordance with Chart 1. In most cases, a blocking condenser should be connected between the output lead of the signal generator and the receiver to prevent a direct current path back to ground which might short out the automatic volume control voltages applied to the control grid as this could cause misalignment.

3. Using the output indicator and connections shown in Chart 1, adjust the trimmer condensers or the iron cores of the inductors for correct alignment.

NOTE: To prevent the possibility of automatic volume control action interferring with correct alignment, use the lowest possible signal level which will give a satisfactory indication of the meter. When making an alignment of receivers that have provision for varying the selectivity of the intermediate frequency stages, turn the selectivity control to the maximum position before making alignment.

b. Oscillator Alignment.

1. All superheterodyne type of receivers have a local oscillator which operates, in most cases, at a frequency which is the sum of the receiver intermediate frequency and the frequency for which the receiver is tuned. In ultra-short wave receivers, however, the oscillator may operate at a frequency which is the difference of the two frequencies. This local oscillator heterodynes with the received signal to produce the intermediate frequency of the receiver.

2. Many oscillators, especially those in the more elaborate receivers, have provisions for tracking the oscillator with the main tuning dial, both at the low and high end of the band. The oscillator is generally tracked at the low end by means of a padder condenser or variable iron core of the oscillator tank coil. The high frequency end of the band is always tracked by means of a trimmer condenser generally connected directly across the oscillator coil or the tuning condenser.

3. Alignment of the oscillator should be started at the low frequency end of the band if provisions are made for tracking at that end.

4. Set the signal generator to produce the desired frequency and tune the receiver to the same frequency. The frequency and connection of the indicating medium is indicated in Chart 1. Make adjustment of the padder condenser or the iron core until correct alignment is obtained.

c. RF Alignment

1. Most receivers, except those of the communication type, have no provisions for tracking the r-f stages at the low frequency end of the dial and, therefore, alignment of the r-f stages is made only at the high frequency end of the dial. In the case of broadcast receivers, this is in the vicinity of 1500 kc. Alignment of r-f stages may be made with the signal either variable r-f or a harmonic of the crystal controlled oscillator. The general procedure is as follows:

(a). Set the signal generator to produce the frequency at the upper end of the band, approximately 1500 kc for broadcast receivers.

(b). Tune the receiver to this frequency.

(c). Connect the indicating means as shown in Chart 1, then adjust the trimmer condensers on the r-f stages for maximum output as indicated by the meter.

## 4.3 FREQUENCY MODULATED RECEIVER ALIGNMENT

### a. Procedure for Alignment of Foster-Seeley Discriminators

When FM receivers were first introduced, the circuits used were almost universally of the IF amplifier, limiter (necessary to remove amplitude modulation from the frequency modulated signal ), and Foster-Seeley type of discriminator. Figure 4.3 illustrates the typical IF and discriminator stages in a receiver of this type of design.

With reference to this figure, the alignment procedure is to feed the frequency modulated signal in at the first detector at the proper IF frequency and, in general, the deviation is adjusted to approximately 200 kc either side of center frequency. The scope is first connected to the limiter load resistance, point "A", and alignment is made of the IF and limiter stages which results in a response curve as illustrated in Figure 4.16. The broadness of the curve is determined by the band pass characteristics of the IF stages and varies from one set to another. Alignment is made to get a maximum vertical deflection of the response curve consistant with symmetrical sides.

After the IF and limiter stages are aligned, the scope is reconnected to the discriminator load resistance at point "B" and the discriminator primary and secondary are adjusted to give a curve as illustrated in Figure 4.7 or 4.11. An incorrect adjustment of the primary will result in a non-linear trace between points "A" and "B" (Fig. 4.10). An incorrect secondary adjustment will result in traces as illustrated in Fig. 4.9. This completes the alignment of the IF, limiter and discriminator stages.

At this point, we would like to deviate from the alignment procedure to point out a factor in connection with the alignment which is often confusing to many servicemen.

For technical reasons beyond the scope of this manual, it is advisable to generate a frequency modulated signal by heterodyning an unmodulated variable frequency oscillator, which in most cases is the main variable oscillator of the signal generator, against a fixed frequency modulated oscillator, and from properly designed mixer circuits, take the desired frequency modulated output. In most signal generators the frequency modulated oscillator operates at approximately 50 mc.

To generate the standard FM intermediate frequency of 10.7 mc, the variable oscillator is adjusted to 10.7 mc above or below the fixed frequency modulated oscillator. In the case being considered, we would probably set the main oscillator at 10.7 mc below 50 mc, or at 39.3 mc.

Considering potential errors in generating a frequency in this manner, we might conceive of an error of as much as 1% in the main variable oscillator. This could result in a frequency error of 1% of 39.3 mc, or .393 mc. Assuming that there might be a similar error in the frequency modulated oscillator, here again, there could be a potential error of .5 mc. If, by some chance, these two errors were in such a direction as to be additive, the potential error might be a total of .393 mc plus .50 mc, or almost .9 mc. At 10.7 mc, this error of .9 mc would represent an error of over 8%.

Some servicemen have made a practice of roughly aligning the IF stages first with a regular amplitude modulated signal which, of course, should be well within an accuracy of ± 1% at 10.7 mc, or .10 mc, and then making the final alignment using an FM signal. When the FM generator is first connected up for this final adjustment, the frequency should be adjusted in the vicinity of 39.3 mc until the response curve is centered on the screen, regardless of whether or not the main dial is indicating exactly 39.3 mc. As the serviceman becomes familiar with a particular signal generator, he will soon learn what errors, if any, exist and then can automatically set the main tuning dial to the frequency which will give him the exact frequency desired.

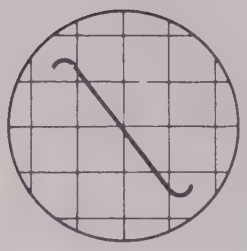


FIG. 4.11

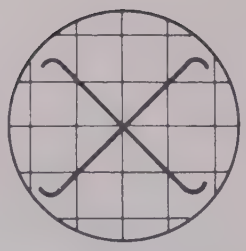


FIG. 4.12

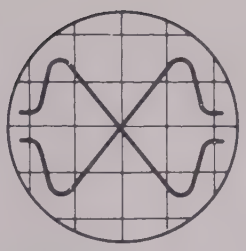


FIG. 4.13

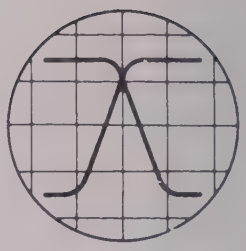


FIG. 4.14

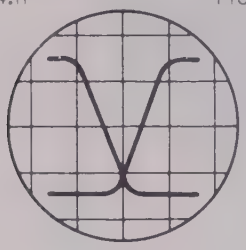


FIG. 4.15

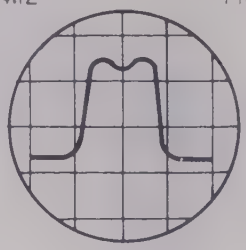


FIG. 4.16

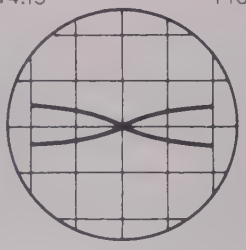


FIG. 4.17

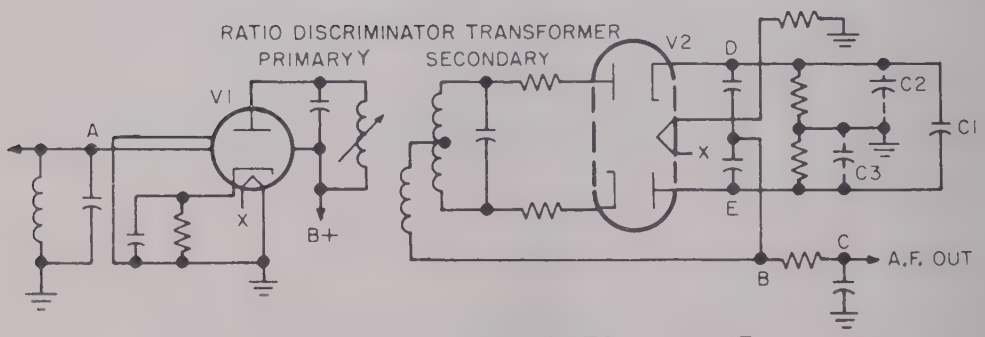



FIG. 4.18 RATIO DISCRIMINATOR CIRCUIT

b. Procedure for Alignment of Ratio Detectors

One major change in circuit design of FM receivers has been the development of the ratio detector. This circuit resulted in the possibility of elimination of the limiter stages since this type of detector is responsive only to frequency changes. Also, this ratio type discriminator circuit produces a DC voltage in proportion to the strength of the incoming carrier wave. This can be used to supply A. V. C. voltage to the IF and RF stages. One form of this type of detector is illustrated in Figure 4. 18. It is not the intention of this discussion to go into the relative merits of the two types of detection as both types find uses in the design of FM receivers.

The alignment procedure of ratio detectors generally takes the following pattern: A frequency modulated signal generator is first fed in at the grid of the last IF amplifier tube, V1, at point "A". A decoupling resistor of several hundred ohms should be connected between the generator output and this point. The signal generator should be set to produce an FM signal of the proper IF frequency and deviation adjusted to about 200 or 300 kc total, that is, 100 to 150 kc either side of center frequency.

The vertical input to the scope is generally connected at either point "B" or point "C". In some cases, it may be connected to the high side of the volume control although a certain amount of phase shift may be encountered by such a connection in some types of receivers. With this connection, the following formula may be used to determine whether or not the signal generator and scope used may have suitable characteristics to properly display a discriminator response curve.

The deflection in inches on the scope screen will be approximately equal to three times the signal generator output in millivolts, divided by the scope sensitivity in millivolts, required per inch deflection. As an example, assume a case of a scope which has a sensitivity of 30 millivolts (0.03 volts) per inch and a signal generator which has a maximum FM output voltage at, for example, 10.7 mc, of about 20 or 30 millivolts. The expected deflection in inches would then be, assuming 30 millivolts output for the generator, three times 30 (= 90) divided by 30, or 3 inches.

There are many scopes on the market today which do not have 30 millivolts sensitivity. Therefore, the use of such a scope would result in much less expected vertical deflection of the pattern. In fact, if the sensitivity were as low as 500 millivolts which is common in some scopes, it would be practically impossible to align discriminator stage only in accordance with the following procedure.

If the scope used has provisions for only a 60 cycle sinusoidal horizontal sweep, proper alignment would result in a pattern as illustrated in Figure 4.11 (200 kc sweep from the generator), or Figure 4.7 (400 kc sweep). If the scope being used also has provisions for 120 cycle linear sweep, then it is possible to obtain what is known as the "X" type of pattern as illustrated in Figure 4.12 (200 kc sweep), or Figure 4.13 (400 kc sweep).

Some scopes do not have provisions for synchronized 120 cycle horizontal sweep. If the scope does not have such provisions but does have provisions for synchronizing a 120 cycle sweep from an external source, it is generally possible to obtain the proper synchronizing voltage by making a connection to the input of the full wave power supply filter of the receiver under test where a 120 cycle frequency will be available.

Correct alignment when using 60 cycles sinusoidal horizontal sweep as illustrated in Figure 4.11 or 4.7, should be obtained by an adjustment of the primary of the ratio discriminator transformer until a pattern of maximum height, between points "A" and "B" is obtained. Then the secondary is aligned to obtain as straight a curve or line as is possible between points "A" and "B", readjusting the primary if necessary.

Experience has shown that with most discriminator stages better and faster alignment can be obtained by the use of a relatively narrow (200 kc) sweep. In the case of certain discriminator transformers the use of a wider sweep has given evidence of misalignment. It is an established fact that in actual operation the discriminator does not operate at a sweep width greater than 150 kc total. Of course, the primary or secondary, or both, may be either tuned by iron core inductive slugs or by trimmer capacitors.

In using the 120 cycle linear sweep, the proper adjustment as previously noted, will be obtained when the pattern as illustrated in Figure 4.12 or 4.13 is observed. In alignment using this type of pattern, the primary is first adjusted to obtain maximum vertical deflection between points "AB" and "A'B'". The secondary is then adjusted until the cross-

over point "C" comes exactly in the center of the screen. Incorrect alignment of the secondary will produce patterns as illustrated in Figure 4. 14 or 4. 15.

Once the correct alignment of the discriminator stages has been effected using 120 cycle sweep as illustrated in Figure 4. 12 or 4.13, a still further check can be made on the alignment as follows:

A perfectly aligned discriminator stage will result in two smaller "X" patterns as illustrated in Figure 4.17 as the signal generator frequency is varied above or below the center frequency to which the curve of Figure 4. 12 was obtained. These smaller "X" patterns at about . 4 mc each side of the center frequency will be of the same amplitude and shape, provided that the circuits are properly aligned. This test has proved to be a quick and highly accurate method of determining correct discriminator adjustment.

In ratio type detectors it is possible to obtain a response curve as illustrated in Figure 4. 16 by utilizing the 60 cycle sinusoidal sweep for horizontal deflection and disconnecting electrolytic capacitor C1, or C2 and C3, as some circuits use two capacitors in place of one, and connecting the vertical input to the scope at points "D" or "E". The secondary of the discriminator transformer can not be properly aligned with such connection, but it is possible to align the primary, or if the signal generator is being fed in at some point in the IF strip farther back toward the converter, the IF stages can be aligned for a symmetrical maximum amplitude pattern as indicated in Figure 4. 16.

The alignment of the intermediate frequency oscillator and RF stages in FM receivers is identical to the procedure followed in the alignment of AM receivers by the visual method, the only difference being the frequencies involved.

## 4. 4 CHECK OF A-F STAGES

### a. Gain of 1st A-F Amplifier Stage

All connections are made in reference to Figure 4.1. Connect the decibel meter either at the primary of the output transformer (Point 1), or across the voice coil of the speaker, and feed a signal in at the grid of the audio frequency output stage (Point 3). Note the reading of the indicating meter, and maintaining the signal level constant, transfer the signal to the grid of the 1st A. F. (Point 5). The gain of the stage can be calculated from the increase in the meter reading. If the tube is a triode, the gain may not exceed 10. However, if it is a pentode, the gain may be as high as 50 or 100.

### b. Gain of 2nd A-F Amplifier Stage

If a sensitive voltmeter such as the Hickok Model 456 is available, the gain of the 2nd a-f amplifier stage may be determined. If an audio frequency output of the Model 288AX is connected in at the grid (Point 3) of the second audio frequency amplifier stage and this stage operates normally, an appreciable signal should be heard at the speaker. The actual gain can be checked by connecting the indicating meter between the plate (point 1) and ground and feeding a signal of known voltage (measured by the sensitive voltmeter) from the Model 288AX in at the grid (point 3). The ratio of the output voltage to the input voltage will be a measure of the stage gain. This stage gain should normally vary between approximately 10 and 50, depending upon the type of tube being used.

## 4. 5 USE OF CRYSTAL CONTROLLED OUTPUT

a. The alignment of the radio frequency stages and the oscillator stage of a receiver is greatly facilitated if the 100 kc or 1000 kc crystal controlled output of the Model 288AX is used, as the entire dial of the broadcast band can be checked every 100 kc or, in the case of short wave receivers, every 1000 kc, with a single setting of the crystal by simple tuning to the harmonics of the crystal controlled oscillator. In addition to the speed with which

this enables the entire band to be checked and calibrated, the crystal accuracy, 0.01%, assures far more accurate results than can normally be obtained by using the continuously variable oscillator.

b. At frequencies over 3 or 4 megacycles, it is not advisable to use the 100 kc crystal for alignment as the harmonics are so close together that they might be wrongly identified and the receiver might be misaligned. This, however, would not be the case when using the 1000 kc crystal since, at these frequencies, its harmonics would be so widely separated that misalignment due to this cause would be practically impossible.

c. In cases where the receiver is badly out of line, it is possible that the wrongly identified harmonic will be tuned in. For example, the dial might be set for 600 kc but the receiver may be so far out of line that it would receive the 7th harmonic (700 kc) better than the 6th. If this error were not detected, the entire receiver would be misaligned. To preclude any possibility of such misalignment, check the receiver dial at 1000 kc using the 1000 kc crystal. It will be at the same position as the 10th harmonic of the 100 kc crystal. The next signal tuned in on the low side of the 10th harmonic position will be the 9th harmonic. This position can now be used as a reference point for the 8th harmonic, etc. This can be repeated in either direction from the 10th harmonic reference point.

d. The short-wave bands of the receiver may be aligned with the use of either the 100 kc crystal or the 1000 kc crystal, using the same general procedure.

## 4.6 FIDELITY MEASUREMENT

a. Fidelity is a quality of reproduction and is determined by a combination of two factors -electrical and tonal. The ear is the measuring stick for the tonal quality. The Model 288AX is used to generate audio frequency output, 0-15 kc. With the use of an output indicator, a fidelity characteristic curve, as shown in Figure 4.19, may be obtained.

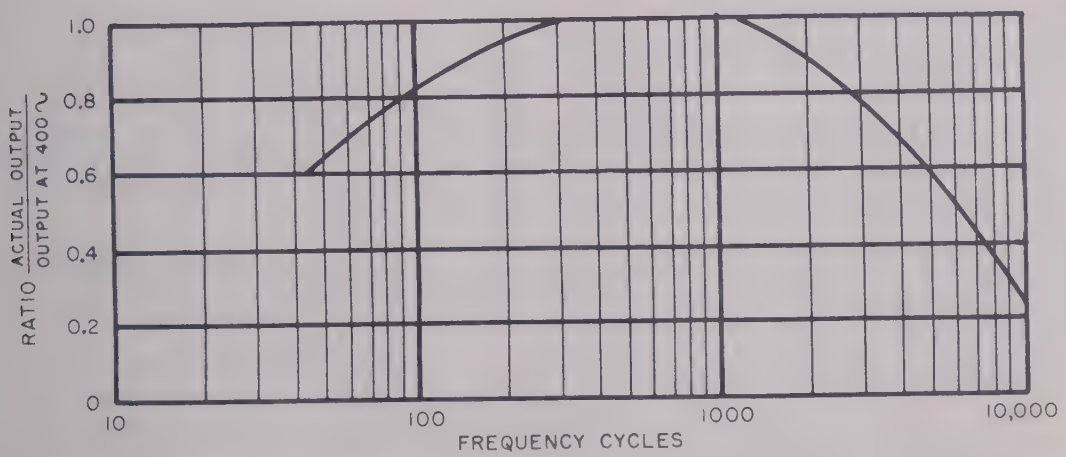



FIG. 4.19 - TYPICAL RECEIVER FIDELITY CURVE

b. To obtain the data necessary for a fidelity curve, proceed as follows:

1. Connect the decibel meter across the voice coil or across the equivalent non-inductive load substituted for it.

2. Connect the output of the Model 288AX, adjust to produce 50 cycles to 15,000 kc, to the input a-f section of the receiver.

3. Adjust the a-f output level of the Model 288AX until a convenient decibel meter reading is obtained with 400 cycles as the audio frequency. It is important that the a-f level delivered to the receiver under test be maintained constant.

4. Vary the frequency from approximately 50 cycles to approximately 10,000 cycles. Note the readings of the decibel meter, taking enough values to obtain sufficient data for a fidelity curve. If the decibel meter is not available, a similar curve would be obtained by plotting voltage readings instead of decibel readings.

## 4.7 TROUBLE-SHOOTING IN RECEIVERS AND OTHER ELECTRONIC DEVICES

a. General - The Model 288AX, when properly used, is a very valuable instrument for locating trouble in electronic devices. In the case of radio receivers it is advisable in locating faults, to start at the speaker or output stage and work back towards the antenna. All following information on trouble-shooting is with reference to the basic circuit of the superheterodyne receiver, illustrated in Figure 4.1.

b. Speaker - Permanent magnet types of speaker can be tested by connecting the audio frequency output from the Model 288AX directly to the voice coil, and varying the frequency throughout the audio range.

c. Output Transformer - The output transformer can be checked by connecting the audio output of the Model 288AX to the primary of the transformer being tested. Due to the step-down ratio of the transformer, very little signal will be obtained at the speaker during this check. Maximum signal output will be obtained at the frequency to which the transformer is tuned. It is imperative in making this test that a blocking condenser be inserted between the output lead and the connection to the transformer.

d. Cathode Bypass Condenser, 2nd A-F Amplifier - A check of the cathode bypass condenser, C1, can be made by connecting the decibel meter across this condenser and feeding a signal in at the grid of the tube. If the condenser is functioning normally, very little voltage should be developed between point 2 and ground. An open bypass condenser would result in a voltage between point 2 and ground equal, approximately, to the signal voltage being applied to the grid. The same would be true of the cathode bypass condenser of the 1st a-f amplifier.

e. Input Condenser - A check of the input coupling condenser, C2, can be made by feeding the signal in at the plate (point 4) of the preceding audio frequency amplifier. No change in output is to be expected if this condenser is operating normally.

f. Volume Control - The volume control can be checked by feeding the signal in at the high end of this control (Point 6). The audio frequency coupling condenser can be checked by connecting to Point 7.

g. Intermediate Frequency Stages

1. Adjust the Model 288AX to produce the proper intermediate frequency for the receiver under test and feed it in at the secondary of the last i-f transformer (Point 8). A signal will be obtained as indicated by the indicating meter. Due to the loading effect of the generator on the secondary of this transformer, tuning will be found to be very broad.

2. Connect the output of the generator to the primary of the last i-f transformer (Point 9). An increase in signal strength may be expected and the broadness of tuning greatly reduced. This is only a test of whether or not the operation of the last i-f transformer is normal, and, under no conditions, should an attempt be made to align the trimmers of the last i-f transformer with connections at point 8 or point 9. Align-

ment should be made with the signal connected at the grid of the second i-f amplifier tube (Point 10).

3. Connect the Model 288AX to the grid of the second i-f amplifier tube (Point 10). An appreciable gain should be indicated either by the increase in the indicating meter reading or by the fact that a smaller signal is required for a given output. The gain will vary between 10 and 25 per stage. The last i-f transformer may be aligned with the signal fed in at Point 10.

4. The output transformer for the first i-f amplifier stage can be checked by connecting the signal to the plate of the tube (Point 11). Normally, very little difference in over-all gain, over and above the amplification which is obtained when feeding in at Point 10, is to be expected when feeding signal in at the primary of this transformer. No attempt should be made to align this transformer with the signal generator connected at Point 10 or 11. However, alignment may be made with the signal connected to the grid of the first i-f amplifier tube (Point 12). In connecting to the grid of this tube, an appreciable gain of 10 or 25 is to be expected.

5. The first i-f amplifier transformer can be checked by connecting to Point 13.

h. Checking 1st Detector Section - In checking the first detector performance, the Model 288AX may be used as a substitute for the local oscillator, if it is thought that the trouble lies in this section. Disconnect the local oscillator, or remove the oscillator tube, and use the signal generator to replace it as a source of voltage for the first detector section. It is necessary either to have two signal generators or to be able to tune the receiver in to a strong local broadcasting station in order to obtain the beat frequency (i. f. ). For example, if the i-f of the receiver under test is 456 kc, and the local broadcast station tuned in were at a frequency of 1000 kc, the Model 288AX should be set to produce 1456 kc, pure r-f, and a beat frequency of 456 kc will result. The signal from the Model 288AX is fed in at the injector grid (Point 14). If all other parts of the receiver are operating normally, the broadcast signal should be received.

i. R-F Stages

1. The signal generator may be used to check the r-f stages by first tuning the receiver to some frequency within the range covered by the receiver - for example, 1000 kc in the case of broadcast receivers. The signal generator output, at a frequency of 1000 kc, may be fed in at the grid of the first detector (Point 15). The reading of the decibel meter should be noted and then the output of the signal generator be connected to the primary of the second r-f transformer (Point 16). An increase in the meter reading will be noted due to the fact that, with the signal generator connected at Point 15, the tuning stage feeding the grid of the 1st detector is thrown out of resonance due to the capacity loading of the signal generator connection. When the signal is connected to Point 16, the transformer operates normally. The secondary of the transformer remains tuned and an overall gain is noted. No attempt should be made to align the trimmer condensers across the r-f transformer with the signal generator connected to these transformer secondaries.

2. By connecting the signal generator to the grid of the first r-f amplifier tube, an increase should also be noted in the output due to the amplifying action of the first r-f amplifier tube. Connection at the antenna post (Point 18) should also give an increased signal.

## SECTION V - MAINTENANCE

### 5.1 GENERAL

As the Model 288AX has been built in accordance with the Hickok high standards of qua-

lity, material and workmanship, no maintenance other than routine checks should be necessary. In the event that trouble occurs, it is suggested that our engineering staff be consulted as they will be glad to give any assistance possible. It is requested that the suggestions given in "Returning Equipment for Repair", Page vii, be followed if it becomes necessary to return the unit.

## 5.2 TUBE MAINTENANCE

Failure in operation, in most cases, is likely to be caused by failure of tubes. These tubes are operated well within their ratings to insure long life but may, in time, need replacing. All tubes except the main variable oscillator, V1, type 6C4, and the crystal controlled oscillator and cathode follower tube, V2, type 6SN7, are easily accessible when the unit is removed from its case. To remove V1 and V2, remove the r-f shield first. The type 6C4, (V1) is a miniature type tube and has a special shield which has to be removed first. To do this turn the shield slightly to release the catch, then lift straight out.

## 5.3 RE-ALIGNMENT

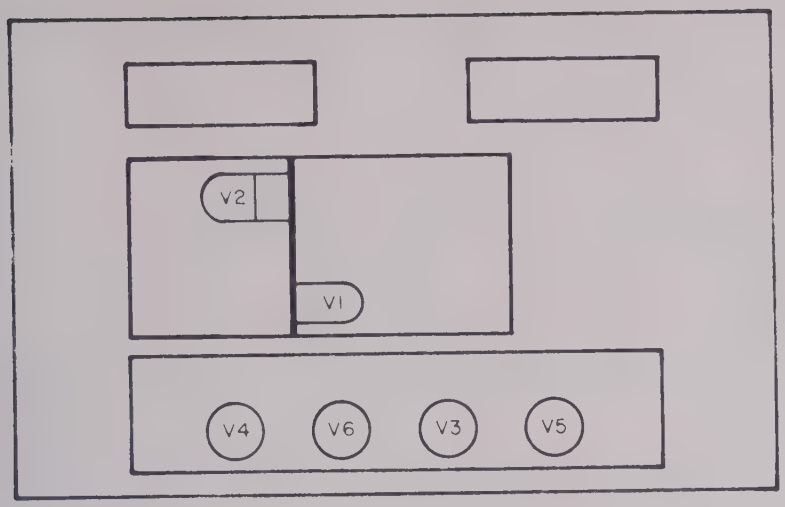
When the 6C4 main variable oscillator tube is replaced, the characteristics of the new tube may differ sufficiently from the replaced tube to necessitate re-alignment of the oscillator unit. Variable powdered-iron core inductors, at the low frequency end, and negative temperature coefficient ceramic capacitors, at the high end of the band, are used for alignment. The Model 288AX is a high precision type of instrument and will need suitable standards to make any realignment. Realignment data is available and will be supplied upon request.

## 5.4 CRYSTAL INSTALLATION

All leads to the crystal are wired in and need only to be connected to the crystal for operation. The crystal may be obtained from the Hickok Electrical Instrument Company, see Parts List, Section VI.

## 5.5 TROUBLESHOOTING

Should trouble develop in the Model 288AX, a voltage and resistance chart is included in Figure 5.1 to facilitate locating the defective circuit in the instrument. Having located the circuit the particular component can best be isolated by individually checking the circuit components. A complete schematic diagram of the Model 288AX is given in Figure 7.1.




| Pin No. | V1<br>6C4 | V2<br>6SN7 | V3<br>6SN7 | V4<br>6SK7 | V5<br>6X5 | V6<br>6SG7 |
|---|---|---|---|---|---|---|
| | + 88 V | - 1.1 V | 0 V | 0 V | 0 V | 0 V |
| 1 | 135 KΩ | 4.7 MΩ | 1500Ω | 0 Ω | 0Ω | 0Ω |
| | | 0 V | + 78 V | 0 V | 0 V | 0 V |
| 2 | I. C. | ∞ Ω | 120 KΩ | 0Ω | 0Ω | 0Ω |
| | 0 V | 0 V | + 3 V | 0 V | 185 V | + 3.8 V |
| 3 | 0Ω | 1800Ω | 470Ω | 100 KΩ | AC | 470Ω |
| | 6.3 V | - 1.6 V | - 15 V | + 7.4 V | | 0 V |
| 4 | AC | 1 MΩ | 56 KΩ | 5.4 KΩ | | ∞ Ω |
| | + 88 V | + 75 V | + 136 V | + 15 V | 185 V | |
| 5 | 135 KΩ | 120 K2 | 86 KΩ | 1500 Ω | AC | NC |
| | - 15 V | + 3.2 V | + 3 V | + 155 V | 55 V | + 138 V |
| 6 | 470 KΩ | 1800Ω | 470Ω | 85 KΩ | AC | 80 KΩ |
| | 0 V | 6.3 V | 6.3 V | 6.3 V | 6.3 V | 6.3 V |
| 7 | 0Ω | AC | AC | AC | AC | AC |
| | | 0 V | 0 V | + 76 V | + 210 V | + 138 V |
| 8 | | 0Ω | 0Ω | 100 KΩ | | 80 KΩ |

Operating Conditions For Above Measurements:

FREQ. MOD. SWEEP - O
BAND SELECTOR - D
FREQ - 1 Mc
OUTPUT - MAX
OUT. MULT - X1000
FM-AM SEL - 1000 KC
OUT. SEL - OFF-EXT
VAR. AUDIO - O
INPUT POWER - 117 V, 60 cps
MEASUREMENTS MADE WITH VTVM FROM TUBE PIN TO GROUND

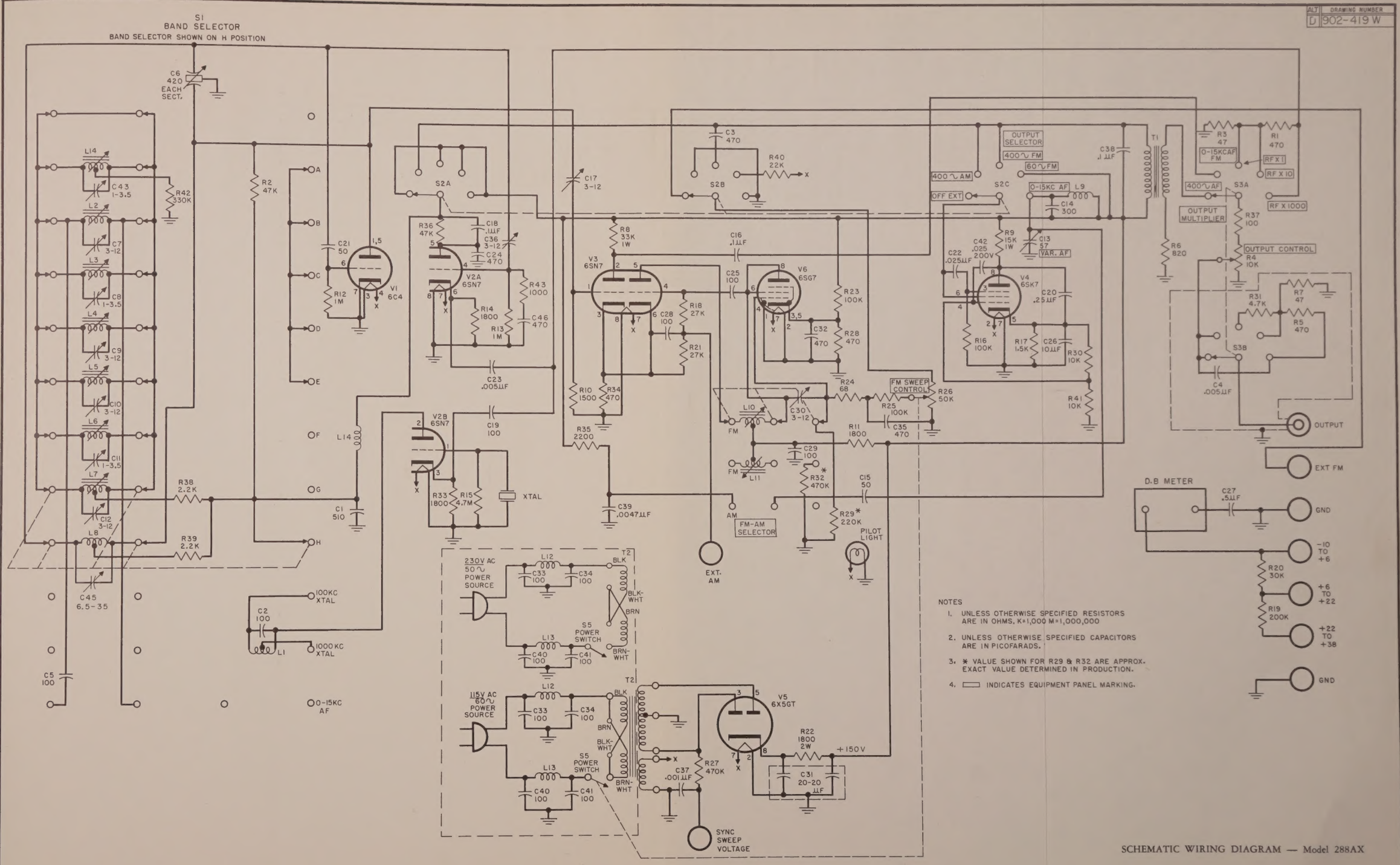
## SECTION VI - PARTS LIST

Reference designations have been assigned to identify all parts used in this instrument. An asterisk designates a part which should be replaced by authorized Hickok repair stations or factories. It is therefore recommended that the entire instrument be returned for repair if trouble exists with such a part.

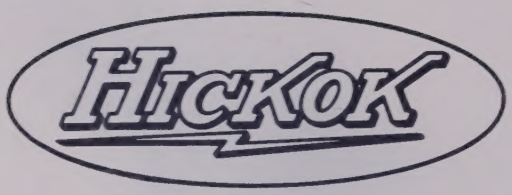
In ordering parts, refer to the current parts price list for this instrument. Prices are subject to change without notice, and the minimum billing charge is $3.50.

| REF. DESIG. | NAME AND DESCRIPTION | HICKOK PART NO. |
|---|---|---|
| C1 | CAPACITOR: 470 μμf, 10%, 500 volts, mica | 3095-8 |
| C2 | CAPACITOR: 100 μμf, 10%, 500 volts, mica | 3095-5 |
| C3 | Same as C1 | |
| C4 | CAPACITOR: .005 μμf, disc, ceramic | |
| C5 | Same as C2 | |
| C6 | CAPACITOR: 420 μμf max, 12.5 μμf min, variable | 3120-25 |
| C7 | CAPACITOR: 3-12 μμf, trimmer, ceramic | 3115-1 |
| C8 | CAPACITOR: 1-3.5 μμf, trimmer | 3115-7 |
| C9, C10 | Same as C7 | |
| C11 | Same as C8 | |
| C12 | Same as C7 | |
| C13 | CAPACITOR: 57 μμf, variable, air | 3120-21 |
| C14 | CAPACITOR: 300 μμf, 10%, 500 volts, mica | 3095-44 |
| C15 | CAPACITOR: 47 μμf, 10%, 500 volts, mica | 3095-27 |
| C16 | CAPACITOR: .10 μf, 400 volts, paper | 3105-24 |
| C17 | Same as C7 | |
| C18 | Same as C16 | |
| C19 | Same as C2 | |
| C20 | CAPACITOR: .25 μf, 400 volts, paper | 3105-13 |
| C21 | CAPACITOR: 50 μμf, ±.5 μμf, ceramic | 3110-1 |
| C22 | CAPACITOR: .025 μf, 400 volts, paper | 3105-7 |
| C23 | Same as C4 | |
| C24 | Same as C1 | |
| C25 | Same as C2 | |
| C26 | CAPACITOR: 10 μf, 25 volts, electrolytic | 3085-1 |
| C27 | CAPACITOR: .5 μf, 200 volts, paper | 3105-15 |
| C28, C29 | Same as C2 | |
| C30 | Same as C7 | |
| C31 | CAPACITOR: 20-20 μf, 450 volts, electrolytic | 3085-7 |
| C32 | Same as C1 | |
| C33, C34 | Same as C2 | |
| C35 | Same as C1 | |
| C36 | Same as C7 | |
| C37 | CAPACITOR: 1000 μμf, 10%, 500 volts, mica | 3095-9 |
| C38 | CAPACITOR: .1 μf, 5%, 400 volts, mylar | 3090-425 |
| C39 | CAPACITOR: .0047 μf | 3095-17 |
| C40, C41 | Same as C2 | |
| C42 | Same as C22 | |
| C43 | Same as C8 | |
| C44 | Not used | |
| C45 | CAPACITOR, VARIABLE: 6.5-35 μμf | 3115-2 |
| C46 | Same as C1 | |
| *L1 | COIL: Oscillator crystal | 3320-37 |
| *L2 | COIL: Oscillator "B" R-F | 3320-30 |
| *L3 | COIL: Oscillator "C" R-F | 3320-31 |
| *L4 | COIL: Oscillator "D" R-F | 3320-32 |
| *L5 | COIL: Oscillator "E" R-F | 3320-33 |
| *L6 | COIL: Oscillator "F" R-F | 3320-34 |
| *L7 | COIL: Oscillator "G" R-F | 3320-35 |
| *L8 | COIL: Oscillator "H" R-F | 3320-36 |
| *L9 | COIL: Oscillator - beat oscillator | 3320-38 |
| *L10 | COIL: High frequency - FM | 3320-21 |
| *L11 | COIL: Low frequency - FM | 3320-12 |
| L12 thru L14 | CHOKE: #32 SSE copper wire, 50 turns | 3250-17 |
| *L15 | COIL: Oscillator "A" R-F | 3320-259 |

| REF. DESIG. | NAME AND DESCRIPTION | HICKOK PART NO. |
|---|---|---|
| M1 | METER: 51XG, decibel meter | 510-258 |
| R1 | RESISTOR: 470 ohms, 10%, 1/2 watt | 18411-472 |
| R2 | RESISTOR: 47,000 ohms, 10%, 1/2 watt | 18413-472 |
| R3 | RESISTOR: 47 ohms, 10%, 1/2 watt | 18410-472 |
| R4 | POTENTIOMETER: 10,000 ohms | 16925-86 |
| R5 | Same as R1 | |
| R6 | RESISTOR: 820 ohms, 5%, 1/2 watt | 18411-821 |
| R7 | Same as R3 | |
| R8 | RESISTOR: 33,000 ohms, 10%, 1 watt | 18423-332 |
| R9 | RESISTOR: 15,000 ohms, 10%, 1 watt | 18423-152 |
| R10 | RESISTOR: 1500 ohms, 10%, 1/2 watt | 18412-152 |
| R11 | RESISTOR: 1800 ohms, 10%, 1/2 watt | 18412-182 |
| R12, R13 | RESISTOR: 1 megohm, 10%, 1/2 watt | 18415-102 |
| R14 | Same as R11 | |
| R15 | RESISTOR: 4.7 megohms, 10%, 1/2 watt | 18415-472 |
| R16 | RESISTOR: 100,000 ohms, 10%, 1/2 watt | 18414-102 |
| R17 | Same as R10 | |
| R18 | RESISTOR: 27,000 ohms, 10%, 1/2 watt | 18413-272 |
| R19 | RESISTOR: 200,000 ohms, 5%, 1/2 watt | 18414-201 |
| R20 | RESISTOR: 30,000 ohms, 5%, 1/2 watt | 18413-301 |
| R21 | Same as R18 | |
| R22 | RESISTOR: 1800 ohms, 10%, 2 watts | 18432-182 |
| R23 | Same as R16 | |
| R24 | RESISTOR: 68 ohms, 10%, 1/2 watt | 18410-682 |
| R25 | Same as R16 | |
| R26 | POTENTIOMETER: 50,000 ohms, with a. c. line switch, wire wound | 16925-87 |
| R27 | RESISTOR: 470,000 ohms, 10%, 1/2 watt | 18414-472 |
| R28 | Same as R1 | |
| R29 | RESISTOR: 220,000 ohms (calibration) | 18414-221 |
| R30 | RESISTOR: 10,000 ohms, 10%, 1/2 watt | 18413-102 |
| R31 | RESISTOR: 4700 ohms, 10%, 1/2 watt | 18412-472 |
| R32 | RESISTOR: calibration | |
| R33 | Same as R11 | |
| R34 | Same as R1 | |
| R35 | RESISTOR: 2200 ohms, 10%, 1/2 watt | 18412-222 |
| R36 | Same as R2 | |
| R37 | RESISTOR: 100 ohms | 18411-102 |
| R38, R39 | Same as R35 | |
| R40 | RESISTOR: 22,000 ohms, 10%, 1/2 watt | 18413-222 |
| R41 | Same as R30 | |
| R42 | Same as R12 | |
| R43 | RESISTOR: 1000 ohms, 10%, 1/2 watt | 18412-102 |
| S1 | SWITCH: 2 ceramic decks, 1 phenolic; 3 sec; 11 pos; rotary; Frequency Band Selector | 19912-486 |
| S2 | SWITCH: 2 sec; 5 pos; rotary; Output Selector | 19912-113 |
| S3 | SWITCH: 2 sec; 5 pos; rotary; Attenuator | 19912-114 |
| S4 | SWITCH: 1 sec; 3 pos; rotary; FM-AM Selector | 19912-112 |
| T1 | TRANSFORMER: Audio | 20800-52 |
| T2 | TRANSFORMER: Power | 20800-311 |
| V1 | TUBE: 6C4 miniature | 20875-62 |
| V2, V3 | TUBE: 6SN7GT | 20875-19 |
| V4 | TUBE: 6SK7 | 20875-18 |
| V5 | TUBE: 6X5GT/G | 20875-22 |
| V6 | TUBE: 6SG7 metal | 20875-63 |
| Y1 | CRYSTAL: Dual frequency | 3870-1 |
| | DIAL ASSEMBLY INDICATOR | 4160-113 |
| | BINDING POST: black | 2360-15 |
| | KNOB: round | 11505-125 |
| | KNOB: pointer | 11505-127 |
| | LAMP: pilot, #47 G. E., 6-8 volts, .15 amp | 12270-12 |
| | LEAD: assembly, red, 48", for meter | 12450-98 |
| | SHIELD: for miniature tube | 19155-96 |
| | SOCKET: octal, crimp-on | 19350-30 |
| | SOCKET: assembly, panel light | 19350-112 |
| | BOOKLET: instructions | 2490-585 |




SCHEMATIC WIRING DIAGRAM — Model 288AX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